

Check with Withers, Aircraft Lab.
Wed. morning, July 8, 1942.

RESTRICTED

TECHNICAL ORDER
No.

HANDBOOK
of
WEIGHT & BALANCE DATA
for the

Model _____ Airplane powered with _____ Model _____ Engine(s)

A.A.F. Serial No. _____ only
M.F. Serial No. _____ only

Manufactured by

(Insert name of contractor)

(Insert city & state)

Contract No. _____

Specification _____



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PUBLISHED BY AUTHORITY

OF

THE COMMANDING GENERAL, ARMY AIR FORCES

BY

THE AIR SERVICE COMMAND

AIR FORCE SECTION

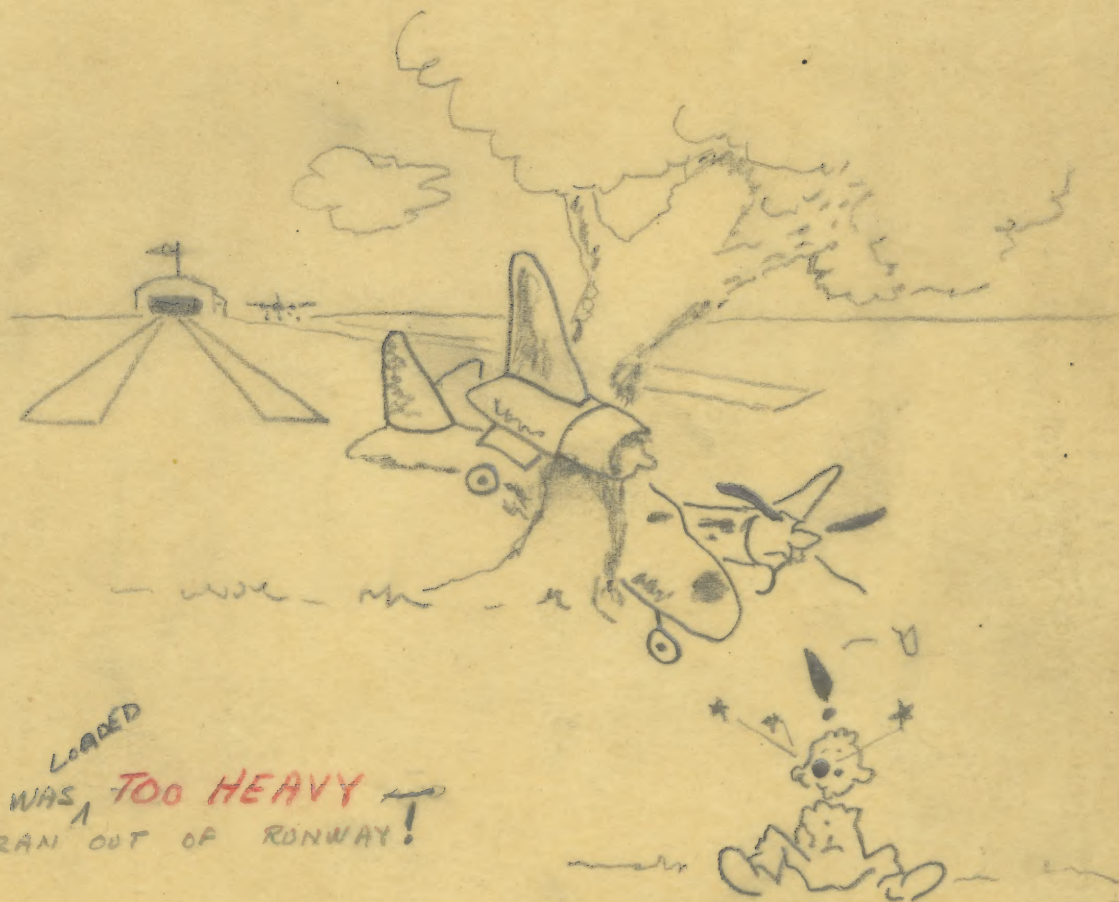
WRIGHT FIELD

DAYTON, OHIO

(Month-Day-Year)

For Miller
7-20-42

Note:
Final copy to
be released by off-set
printing to 8 1/2 x 11

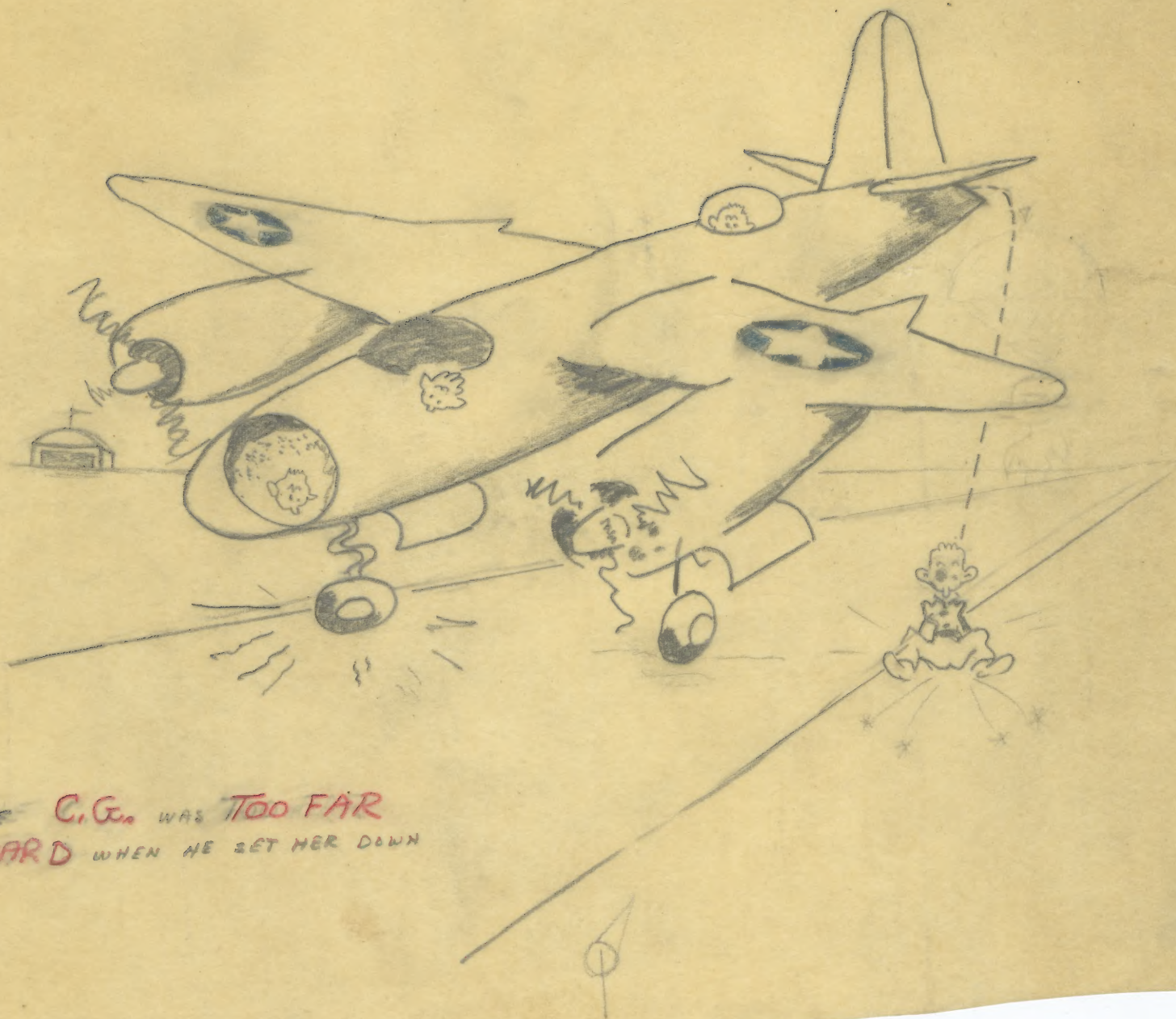


LOADED
SHE WAS ¹ TOO HEAVY
HE RAN OUT OF RUNWAY!



C.G. TOO FAR AFT —
HE CANT GET HIS TAIL UP

17



THE C.G. WAS TOO FAR
FORWARD WHEN HE SET HER DOWN

Restricted

Weight & Balance Control Record
~~WEIGHT AND BALANCE DATA AND RECORD~~

SQUADRON AIRPLANE NO. _____ ORGANIZATION _____
STATION _____

AIRPLANE MODEL A.A.F. SERIAL NO. ~~DATE PURCHASED~~
MFG. SERIAL NO.

more lateral room required

SQUADRON ENGINEERING OFFICERS

NAME	GRADE	DATE ASSIGNED	DATE RELIEVED	NAME	GRADE	DATE ASSIGNED	DATE RELIEVED
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
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CREW CHIEFS

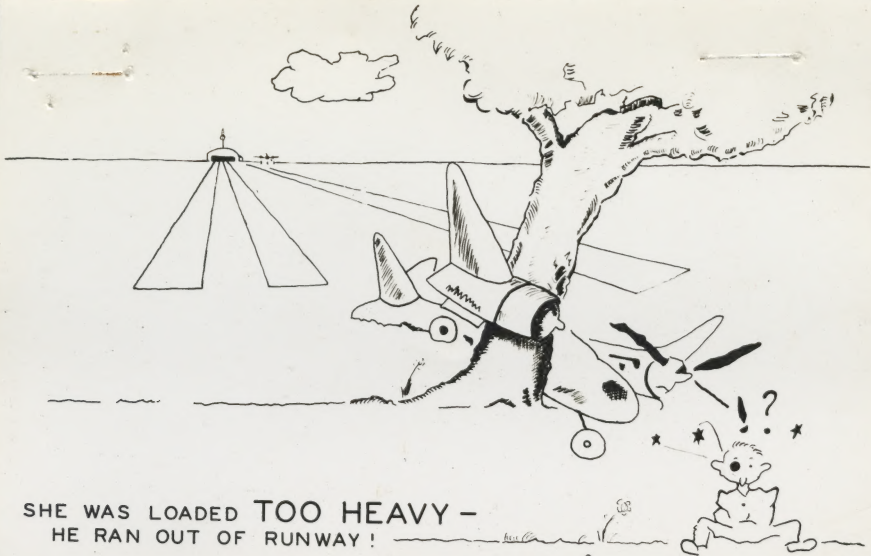
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_____	_____	_____	_____	_____	_____	_____	_____

(Composing Room note: Please rearrange this sheet to include all data not marked out, and allow a little more room for the signature appearing between lines. Make originals on our standard oversize sheets for subsequent reduction and printing by offset methods. The form may set vertically on the page OK (Shank)

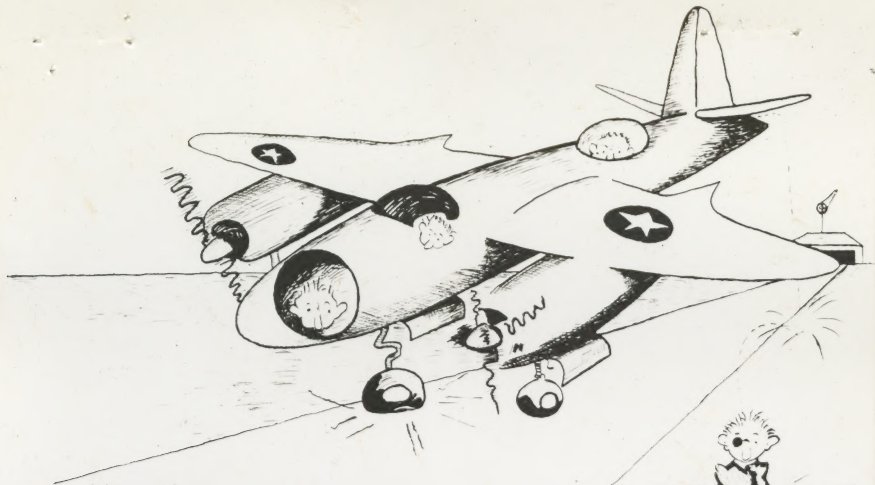
Restricted

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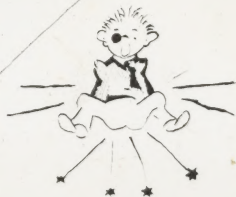
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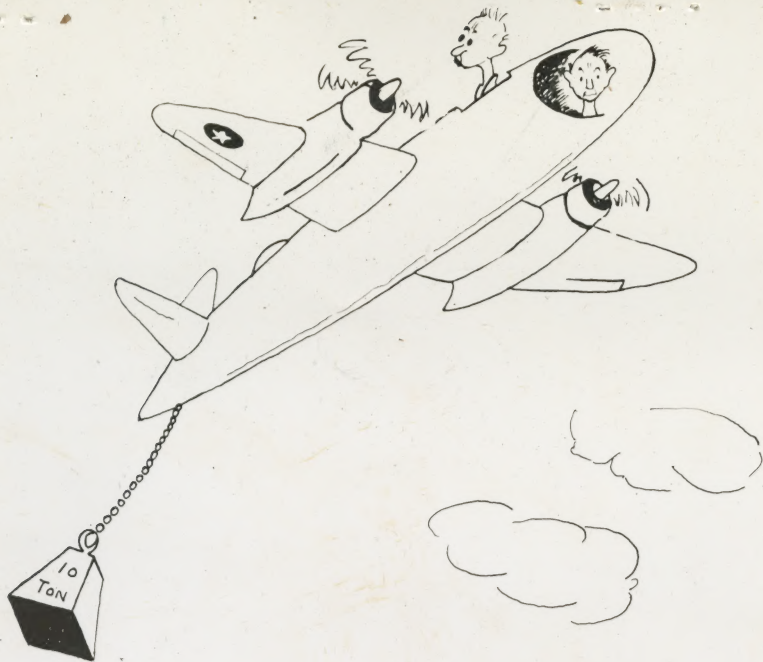


SHE WAS LOADED **TOO HEAVY** -
HE RAN OUT OF RUNWAY !



THE CG WAS TOO FAR
FORWARD WHEN HE SET HER DOWN!





CG TOO FAR AFT -
HE CAN'T GET HIS TAIL UP.

SECTION I
INTRODUCTION1. APPLICATION

a. This Technical Order contains all information and blank forms necessary to provide a perpetual record and control of the Weight & Balance of the airplane whose model and serial numbers appear on both the Title page and the "Weight & Balance Control Record" sheet.

CAUTION: Data inserted on the charts and forms provided herein are applicable only to the individual airplane whose serial number appears on both the Title page and the "Weight & Balance Control Record" sheet. Corresponding serial number identification determines to which airplane the book is applicable. This individual book must remain in the particular airplane to which it is assigned.

2. PURPOSE OF THIS WEIGHT & BALANCE CONTROL SYSTEM.

a. To provide an Army Air Force standard system of Weight & Balance Control and to increase the speed, range, operating efficiency and safety of aircraft.

b. A system is essential because:

- (1) Equipment, operations and personnel are being rapidly increased.
- (2) Weight and balance limits are in general becoming more critical.
- (3) Heavier loads are being carried.
- (4) There is a greater necessity for optimum range and speed.
- (5) Missions and loadings are becoming more varied.
- (6) An error in loading will mean an accident.

c. The purpose of a standard weight and balance system is to:

- (1) Eliminate confusion as to limits, forms and procedures.
- (2) Provide a quick and accurate method of loading and balancing within required limits.
- (3) Prevent accidents that might be caused by improper weight and balance conditions.
- (4) Fix responsibility for improper conditions.

3. EFFECT OF WEIGHT AND BALANCE ON SAFETY

a. Overweight:

- (1) Higher stalling speed.
- (2) Lowering of stress factors--danger, rough air, or take-offs from poor fields.
- (3) Lowering of maneuverability.
- (4) Increased take-off run.
- (5) Lower angle and rate of climb.
- (6) Decreased ceiling.
- (7) Increased fuel consumption for given speed--decrease in miles per gallon.
- (8) Lower tire factors.

(INSERT FIGURE 1 HERE) $3\frac{1}{4}$ "

b. Balance too far forward:

- (1) Increased fuel consumption--less range.
- (2) Increase of power for given speed.
- (3) Increased oscillation tendency.
- (4) Tendency to increase dive beyond control.
- (5) Flap operation might cause critical condition.
- (6) Difficulty in getting nose up in landing.
- (7) Overstresses nose wheel.
- (8) Dangerous condition if tail structure is damaged or surface shot away.

(INSERT FIGURE 2 HERE) $3\frac{1}{2}$ "

c. Balance too far aft:

- (1) Creates neutrally stable to unstable condition.
- (2) Increase of stall tendency.
- (3) Definitely limits low power--might adversely affect long range optimum speed.
- (4) Up gust might cause stall before possible recovery.
- (5) Decreases speed.
- (6) Decreases range.
- (7) Aggravates deicer effect on high-wing aircraft.
- (8) Increases pilot strain in instrument flying.
- (9) Dangerous condition if tail structure is damaged or surfaces shot away.

(INSERT FIGURE 3 HERE) $5\frac{1}{4}$ "

START
AT TOP

SECTION II GENERAL INSTRUCTIONS

1. CHARTS AND FORMS

a. The system of Weight & Balance Control provided herein requires the use of five different charts and one Clearance Form. The clearance is furnished in a pad form with provisions for making an original and a duplicate copy, the former to be detached before take-off and furnished Operations as evidence of correct airplane loading and the latter to remain with the pad as a record. The charts and forms are identified as follows:

- (1) Chart "A" Basic Weight Check List.
- (2) Chart "B" Record of Structural Changes.
- (3) Chart "C" Running Log-Basic Weight and Balance.
- (4) Chart "D" Cargo (or Supply) List.
- (5) Chart "E" Charts and Graphs.
- (6) Form "F" Weight & Balance Clearance.

b. The airplane manufacturer inserted all airplane identifying data on the Title Page and the Weight & Balance Control Record sheet, and complete all applicable charts and one sample "Weight & Balance Clearance (Form F)" at time of delivery. This will constitute the Basic Weight and Balance of the airplane at delivery, and all subsequent changes in weight and balance will be compiled by the Army Air Forces in accordance with instructions contained in this Technical Order.

c. Detailed instructions for filling in each of the charts and forms listed under paragraph 1. a. will be found printed on the page preceding the first sheet of each chart or form.

(1) Charts "A", "B", and "C" will be checked and brought up to date at the following intervals:

- (a) When the airplane is received at a new base.
- (b) When modifications or structural changes are made.
- (c) When engines are changed.
- (d) When the airplane has a major overhaul or is repaired.
- (e) When changes in equipment are made for a different type of operation or mission.
- (f) When a pilot reports an abnormal balance condition during operations.
- (g) When it is suspected that the forms are not up-to-date.
- (h) When the airplane is reweighed.

(2) Chart "D" will be filled out for every flight unless no change in the items listed thereon permits use of the previous flight figures.

(3) Form "F"- Weight & Balance Clearance page is filled out by the airplane manufacturer. One copy of the expendable book of Weight &

Balance Clearance forms will be made out and approved by the pilot prior to every flight.

NOTE: Form "F" is furnished in two styles; viz: one copy is permanently fixed in this book with the word "ORIGINAL" overprinted in red ink. This sheet was filled out by the manufacturer as part of the original weight and balance record at delivery of the airplane, and will remain forever in this book as a permanent record, and as a guide to flight personnel for filling out subsequent clearances.

The second style Form "F" is provided as an expendable pad of blank clearance sheets which can be replaced when exhausted. These pads are loose leaf style, with provisions for making a duplicate copy. All original sheets are perforated along the top and may be removed and furnished Operations as a weight and balance clearance. Duplicate copies will remain in the pad until all originals in the pad are exhausted. Exhausted clearance pads will be removed from this book and turned in at Operations in exchange for a new pad of clearance forms.

2. DEFINITIONS

a. For the purpose of clarification and standardization the following definitions will govern compiling of all data.

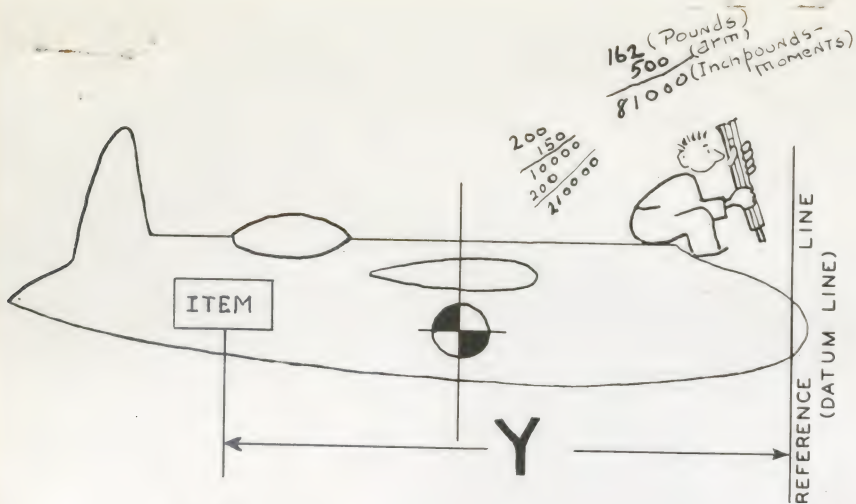
(1) Reference Line (Sometimes called the datum line): An imaginary vertical line at or near the nose of the airplane. Its location is chosen by the manufacturer is a standard point from which all horizontal distances are measured. Diagrams of each airplane show this reference line as zero.

(2) Weight: Sixteen ounces per pound, avoirdupois weight. All data will be calculated to the nearest whole pound.

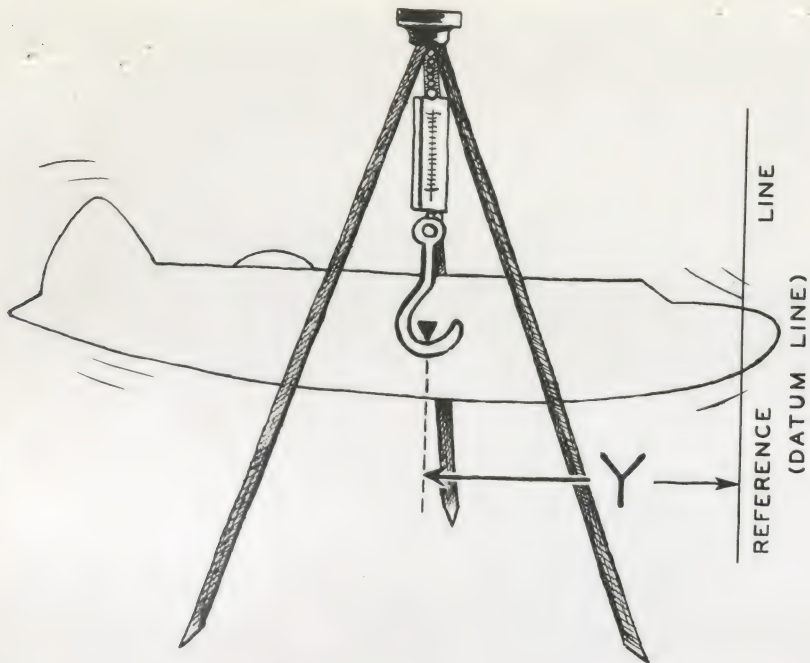
(a) Basic Weight is the weight of the airplane with normal fixed and operating equipment only, i.e., airframe; power plant and accessories; trapped (residual) gasoline, oil, hydraulic and cooling fluids; armor plate; ordnance (less ammunition and bombs); chemical, navigation, oxygen, and pyrotechnic and radio equipment. It does not include any variable items of load or equipment, or items that do not have a fixed location.

(b) Gross Weight is the total weight of an airplane and its contents. DESIGN GROSS WEIGHT is the intended normal operating weight. ALLOWABLE MAXIMUM GROSS WEIGHT is Design Gross Weight plus overload. Any loading that exceeds this allowable limit may cause structural failure of parts or dangerous flight characteristics.

(3) ARM: For any item, arm is its hori-



Y X ITEM WEIGHT IN POUNDS = MOMENT



$Y \times \text{AIRPLANE WEIGHT} = \text{BALANCE MOMENT}$



TO FIND THE NEW CG WHEN ADDING ITEMS
AFTER BASIC AIRPLANE HAS BEEN WEIGHED
AND ITS BALANCE DETERMINED, USE THE FOLLOWING

FORMULA: $\frac{K}{X}$ = NEW GROSS WEIGHT CG

<u>EXAMPLE</u> :	WEIGHT OF ITEM	A	X	ARM	=	INCH	POUNDS
	"	"	B	X	=	INCH	POUNDS
	"	"	C	X	=	INCH	POUNDS
	"	"	D	X	=	INCH	POUNDS

	PLUS	TOTAL WEIGHT OF ADDED ITEMS
		AIRPLANE BASIC WEIGHT
EQUALS		X (NEW GROSS WEIGHT)

	TOTAL INCH POUNDS
	BASIC AIRPLANE BAL. MOMENT
	K (NEW BALANCE MOMENT)

zontal distance in inches from the reference line.

(4) Average Arm or location is obtained by adding the weights and the moments of a number of items and dividing the total moment by the total weight.

Moment: The weight of an item multiplied by its arm.

(INSERT FIGURE 4 HERE) $3\frac{1}{4}"$

Basic Moment is the sum of the moments of all the items making up the basic weight. When using data from an actual weighing of an airplane, the basic moment is the basic weight multiplied by the arm of the center of gravity.

(INSERT FIGURE 5 HERE) $4\frac{7}{8}"$

(5) Center of Gravity: The point about which an airplane would balance if suspended. The location from the reference line is found by dividing the total moment by the total weight of the airplane. As all items of weight or load put into the airplane affect the location of the center of gravity, it is essential that the loads be distributed fore and aft so that the final center of gravity location is within safe limits as described in the following paragraph.

(INSERT FIGURE 6 HERE) $3\frac{1}{2}"$

Allowable Center of Gravity Location: The range of movement which the center of gravity (cg) can have without making the airplane unsafe to fly. It is determined by the manufacturer in actual test flights and is expressed as Forward Limit and Rearward (aft) Limit in inches (arm) from the reference line. The cg of the loaded airplane must be within these limits at take-off, in the air, and on landing. In some cases a special Landing Limit is specified. In all cases the cg condition should be checked for landing without fuel and bombs.

(6) LOADING RANGE: The safe cg location under any load condition.

3. ACTUAL WEIGHING OF BASIC AIRPLANE.

a. When it becomes necessary to check the Basic Weight and Moment carried in the RUNNING LOG (Chart "C"), the airplane shall be weighed in the following manner:

(1) Check the airplane against the CHECK LIST (Chart "A") to determine the equipment which is installed. The CHECK LIST is then checked against the RUNNING LOG (Charts C & C-1) to determine whether or not the BASIC WEIGHT and MOMENT are up to date. After the BASIC WEIGHT and balance status of the airplane are determined from the RUNNING LOG, the airplane is inspected for items of variable load such as fuel, oil, bombs, ammunition, cargo, etc. All bombs, ammunition, cargo,

etc. should be removed from the airplane, and the fuel and oil tanks should preferably be drained. However, the airplane may be weighed with known amounts of fuel and oil in the tanks but the weight and moment of whatever amount of these two items is in the airplane at time of weighing must be deducted from the actual weight and moment (arrived at when weighing) to obtain the actual BASIC WEIGHT and balance of the airplane.

(2) After the airplane is prepared for weighing in accordance with instructions contained in paragraph 3. a. (1), place scales of suitable capacity under each wheel and skid. The airplane must be leveled longitudinally, and, if possible, it should be leveled laterally. Longitudinal leveling lugs are attached to the lower longeron on the left side of the bomb bay. Lateral leveling lugs are located on the lower chord of the rear spar on the left side of the bomb bay. A spirit level shall be used as the leveling instrument.

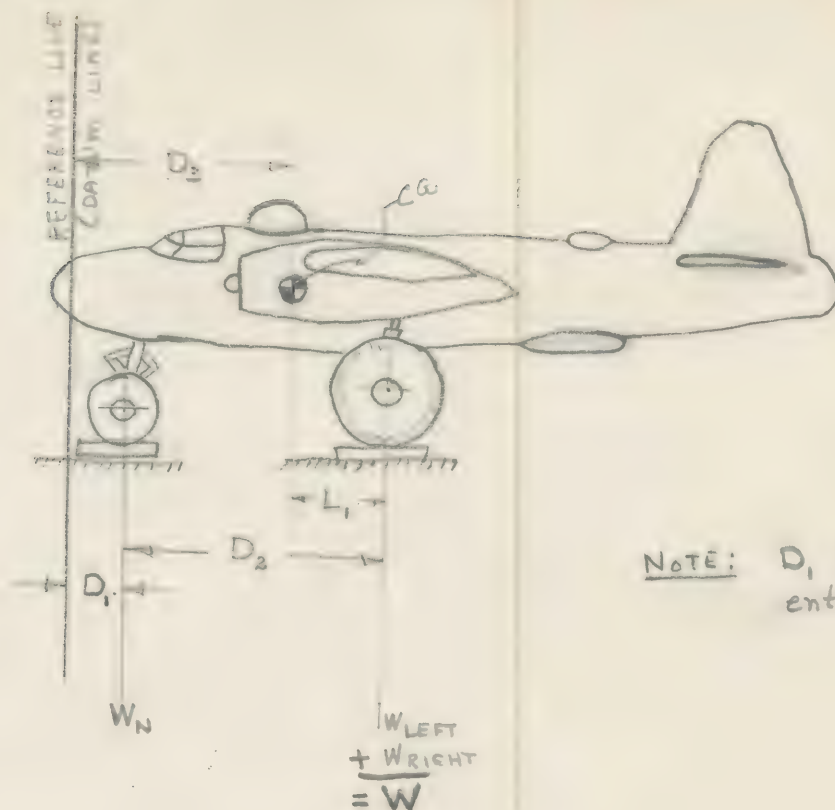
CAUTION: Great care must be exercised when rolling a heavy airplane upon the platform of scales as a rough or abrupt application of the airplane weight might seriously disturb the calibration of the scales and cause them to be inaccurate.

(3) The scale readings should be entered in their appropriate places on the Basic Weight & Balance Diagram. The new BASIC WEIGHT and moment may be computed by application of the formulae given in the appropriate Basic Weight & Balance Diagram, and all arithmetic may be entered in the applicable spaces provided.

(4) The new BASIC WEIGHT and moment shall be entered in the RUNNING LOG (Chart "C") and all subsequent airplane loading will be based on these figures.

NOTE: A small difference between the new actual BASIC WEIGHT and moment, and the BASIC WEIGHT and moment determined from the RUNNING LOG (Chart "C") may be present. This difference may be due to "Service Pickup" (Dirt, etc) and will be small if careful work has been done in keeping the Check List (Chart "A") and RUNNING LOG (Chart "C") up to date.

BASIC WEIGHT & BALANCE DIAGRAM (FOR NOSE WHEEL AIRCRAFT)



NOTE: D_1 & D_2 to be entered in inches.

ITEM NO.	POSITION OF SCALES	SCALE READING IN POUNDS	TARE WT.	NET WEIGHT	SYMBOL
(1)	LEFT MAIN WHEEL				W_L
(2)	RIGHT MAIN WHEEL				W_R
(3)	NOSE WHEEL				W_N
(4)	TOTAL (BASIC WEIGHT)				W

(5) THE HORIZONTAL DISTANCE FROM THE MAIN LANDING WHEELS TO THE CENTER OF GRAVITY (CG) IS COMPUTED AS FOLLOWS:

$$L_1 = \frac{W_N \times D_2}{W}$$

(6) THE HORIZONTAL DISTANCE FROM THE CENTER OF GRAVITY (CG) TO THE REFERENCE LINE (DATUM LINE) IS COMPUTED AS FOLLOWS:

$$D_3 = D_1 + D_2 - L_1$$

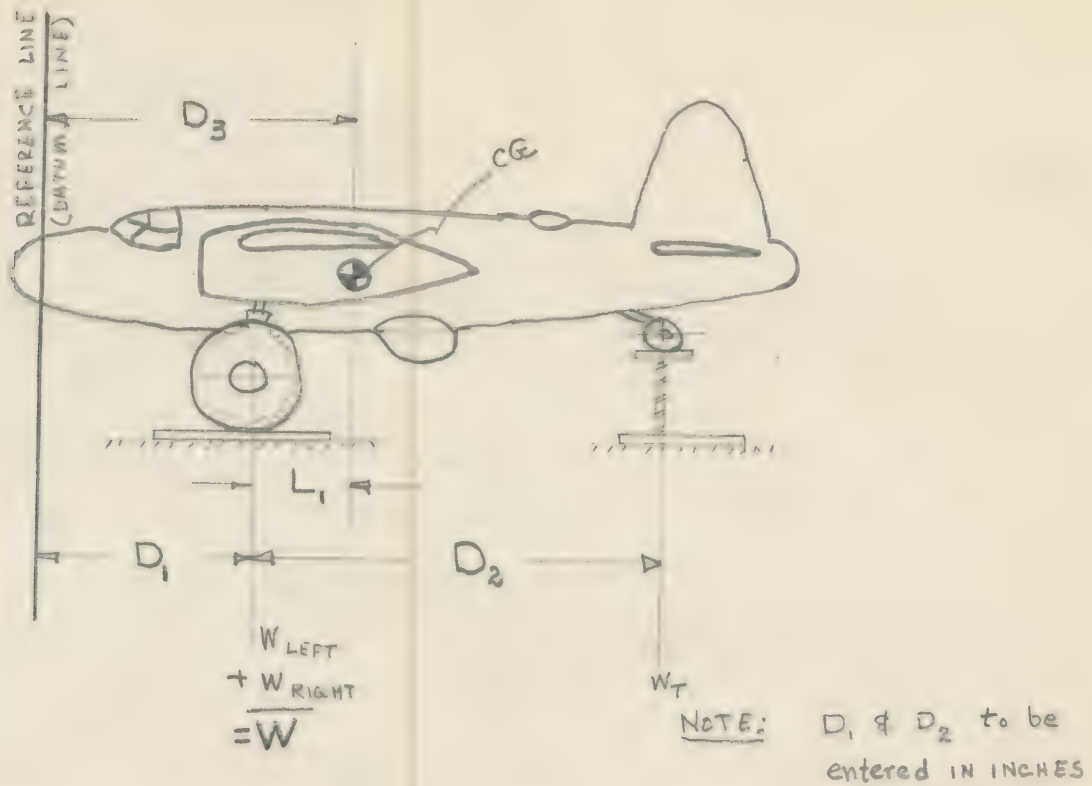
ITEM NO.	DESCRIPTION	WEIGHT	HORIZONTAL DISTANCE FROM DATUM LINE	* MOMENT CONSTANT ()
(7)	AIRCRAFT AS WEIGHED	W (4)	(6)	
(8)**	OIL IN AIRCRAFT (IF ANY)			
(9)**	FUEL IN AIRCRAFT (IF ANY)			

** ADD OR SUBTRACT (AS APPLICABLE) WITH AID OF GRAPH (CHART "E") OR LOAD ADJUSTER.

* THIS RESULTANT FIGURE IS THE "INDEX" APPLICABLE TO THE LOAD ADJUSTER.

Note: 1
1000 lbs
9.81

BASIC WEIGHT & BALANCE DIAGRAM (FOR TAIL WHEEL AIRCRAFT)



ITEM NO.	POSITION OF SCALES	SCALE READING IN POUNDS	TARE WT.	NET WEIGHT	SYMBOL
(1)	LEFT MAIN WHEEL				W_L
(2)	RIGHT MAIN WHEEL				W_R
(3)	TAIL WHEEL				W_T
(4)	TOTAL (BASIC WEIGHT)				W

- (5) THE HORIZONTAL DISTANCE FROM THE MAIN LANDING WHEELS TO THE CENTER OF GRAVITY (CG) IS COMPUTED AS FOLLOWS:

$$L_1 = \frac{W_T \times D_2}{W}$$

- (6) THE HORIZONTAL DISTANCE FROM THE CENTER OF GRAVITY (CG) TO THE REFERENCE LINE (DATUM LINE) IS COMPUTED AS FOLLOWS:

$$D_3 = D_1 + L_1$$

ITEM NO.	DESCRIPTION	WEIGHT	HORIZONTAL DISTANCE FROM DATUM LINE	* MOMENT CONSTANT ()
(7)	AIRPLANE AS WEIGHED	$W(4)$	(6)	
(8)**	OIL IN AIRPLANE (IF ANY)			
(9)**	FUEL IN AIRPLANE (IF ANY)			

- ** ADD OR SUBTRACT (AS APPLICABLE) WITH AID OF GRAPH (CHART "E") OR LEAD ADJUSTER
- * THIS RESULTANT FIGURE IS THE BASIC "INDEX" APPLICABLE TO THE LOAD ADJUSTER

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SECTION III
INSTRUCTIONS FOR COMPILING
THE BASIC WEIGHT CHECK LIST, CHART "A"

1. General Instructions-

a. This form is a check-off list for all fixed and operating equipment (such as machine guns, cameras, etc.) which (1) has a definite location in the airplane, (2) is in the airplane at all times, and (3) weighs five pounds or more.

b. At the time of delivery of a new airplane, the manufacturer enters the above items on this form, in groups according to station location. This list should be as complete as possible, including items that may not be in the airplane, but which might be installed as permanent equipment at some later date. This list should be kept up-to-date.

c. On airplanes delivered prior to the installation of this system, the Weight and Balance Officer prepares the equipment check list and makes additions to the list as new items appear.

d. A check (✓) in the airplane column by a checker indicates that an item was actually installed in the airplane on the date at the head of the column. A check (✓) in the log entry column indicates that the item's weight and moment is included in the latest weight and balance figures shown on Chart "C" (Log). Items should not be checked unless they are installed in place and items not checked are not included in the Basic Weight and Balance total.

e. When an item is added to the airplane, check it in the last used "airplane" column (if space permits) with the date noted after the item name. Add weight and moment on Chart "C" and then check (✓) the "log entry" column. If it is a new item, write in the name or description under the proper station.

f. When an item is removed from the airplane, cross off the check mark in the "airplane" column, subtract the weight and moment on Chart "C" and then cross off the "log entry" check mark.

center in page.

A-1

BASIC WEIGHT CHECK LIST (CONTINUED)

[illegible]

Some chart as on page -12-
of this copy.

SECTION IV ~~()~~
INSTRUCTIONS FOR COMPILING THE RECORD
OF STRUCTURAL CHANGES, CHART "B"

1. This form serves as an historical record of structural changes, and ~~of~~ replacements of major items of equipment, such as: engines, propellers, cowlings, tires, turrets, ordnance installations, armor plate, and so forth.

2. All structural changes, alterations, or major modifications of equipment should be recorded on this form and transferred to Chart "C" (Running Log of Basic Weight and Balance).

3. The manufacturer ^{made} ~~has~~ no entries on this form unless modifications or changes ~~are~~ ^{were} made after weighing and determining basic weight and balance. Entries are made by a weight ^{actual} [and balance Engineering Officer, or his authorized assistant, or by an engineering officer at an overhaul or Modification Center, as follows:

a. Column 1. Enter date of change.

b. Column 2. Enter sufficient description of change to identify it. Enter Order Number of all changes authorized.

c. Column 3. Enter net weight increase or decrease (+ or -).

d. Column 4. Enter arm at which the center of gravity of the change in weight occurred.

e. Column 5. Enter the moment increase or decrease (+ or -). This moment can be computed by the following equation:

$$\text{Moment} = \frac{\text{Weight (lbs.)} \times \text{Arm (inches)}}{\text{Constant ()}}$$

NOTE:
 Columns 3 and 5. Transfer total weight and moment of each entry to Chart "C" (Log).

Center on page both
ways

Same chart that is on page
13 (chart "B")

Same chart that is on page
13 & 14 (Chart "B")

SECTION ~~II~~ ^V (CONTINUED)
 INSTRUCTIONS FOR COMPILING THE RUNNING
 LOG OF BASIC WEIGHT & BALANCE, CHART "C" & "C-1"

1. General.

a. This ~~form~~ ^{chart} is a ~~running~~ ^{permanent} record of the airplane's weight and balance with equipment in place, both fixed and operating, ~~which is considered permanent~~. Trapped (residual) fuel and oil, ~~and~~ coolant and hydraulic fluid are included. The weight and balance data shown on this chart are called the Basic Weight and Balance. At all times the last weight and balance entry is considered the current weight and balance status of the airplane.

b. At the delivery of a new airplane, the manufacturer ~~will~~ ^{basic} enter on this chart the Basic Weight and Balance of the airplane. The equipment included, which ~~will be~~ ^{is} the normal fixed and operating equipment only, as described above, will be shown on chart "A" (Basic Weight Check List).

c. On airplanes delivered prior to the installation of this system, the information will be entered by a weight and balance Engineering Officer, or his authorized assistant, after an actual weighing of the airplane with equipment in place as noted on chart "A", (Basic Weight Check List).

d. Whenever equipment is added or removed, it should be entered on chart "A" for checking purposes and also on this chart "C" with weight and moment added to, or subtracted from, the previous total.

CAUTION:

e. Modifications or structural changes are first recorded on chart "B" and the net change in weight and moment is added to, or subtracted from, the previous total weight and moment shown on chart "C".

f. The effect of changes in equipment as transferred from chart "A" and of modifications or structural changes from chart "B" keep the Log (chart "C") up-to-date and correct.

g. Changes resulting from orders should carry a reference on chart "C" to the order number authorizing the change.

*Center in page
 and horizontally and
 vertically*

If the index of the airplane is changed due to varying ^{the} fixed equipment or ~~adding~~ ^{in the airplane}, ~~structural changes~~ ^{the index marks} on the body of the ~~case~~ ^{identification} ~~card~~ ^{card} must be changed to agree.

RUNNING LOG — BASIC WEIGHT & BALANCE (CONTINUED)

[illegible]

Same chart as shown on page 18 (Chart C-1)

Same chart as shown on page -18- (chart C-1)

Same chat antenna on page -18- (chart c-1)

VI
SECTION ~~II~~
INSTRUCTIONS FOR COMPILING THE
CARGO (OR SUPPLY) LIST, CHART "D"

1. General.

a. This form is used to supplement Form "F" (Weight and Balance Clearance) for load items that are not accounted for elsewhere, such as: crew baggage, freight or cargo of any kind, miscellaneous equipment, supplies, spare parts, stowed parts of the airplane itself, and other items that do not have a fixed location, are not in their normal installation location, or that vary with each flight. Items listed hereon will not be included on chart "A".

b. At the time of delivery of a new airplane the manufacturer ~~will~~, by a second superimposed printing, supply an initial list of items described in paragraph 1 above, which will be supplemented from time to time by A.A.F. weight and balance personnel. This list will be printed in the first five columns (Box No. ~~(if any)~~), Quantity, Item, Normal Location, and Weight) of Form "D". On airplanes delivered prior to the installation of this system this information will be supplied entirely by A.A.F. weight and balance personnel.

c. As each item is put in the airplane its weight shall be entered in the Station column (A, B, C, D, etc.) in which it is loaded, opposite the item description. Any additional load items not appearing on the list compiled in accordance with paragraph 2 above, must be entered in the Item column. *12*

d. When all items are loaded, total each station at the bottom of the page and carry these totals forward to the next page. Enter the final totals in Section X (Station Loadings) of Form "F".

e. In making up the list, some items that are standard equipment, but which vary according to the mission of the airplane, may be listed in groups and accounted for when placed in the airplane. Such items might be supplies or equipment -- Quartermaster, Medical, Signal Corps, Ordnance (not including fixed guns, bombs, or ammunition) spare part, etc.

*Corrected naturally
by page 1*

MISSION

FROM

To

DATE:

DATE _____ AIRPLANE TYPE Model

A.A.F. SERIAL NO.

MFR. SERIAL NO.

17

A.A.F. SERIAL NO.

MFR. SERIAL NO.

[illegible]

5 pages
of the
chart

- 28 -
- 24 -
- 25 -
- 26 -
- 27 -

301 } total adjustment
332

33

SECTION VII
INSTRUCTIONS FOR USE OF THE LOAD ADJUSTER OR GRAPHS
(When compiling the "Weight & Balance Clearance" form "F")

1. Instructions For Use of a Load Adjuster (Slide Rule Type)

NOTE: It is not necessary to use the graph system when a load adjuster is available.

a. Carrying Case - The load adjuster carrying case is constructed of leather, and is provided with an identification card window near the flap.

(1) Inscribed on the identification card is the airplane serial number to which the data printed thereon is applicable. Additional information usually consists of the airplane model designation, the basic and gross load weights, and the basic airplane balance INDEX number for that particular airplane. (Refer to Fig. 1)

b. Type - The load adjuster is of the slide rule type and contains three major parts, the frame, the slide and the indicator. The functions of these three parts are described as follows: (Refer to Fig. 1)

(1) The main "frame" is slotted in the center to receive and permit longitudinal movement of a "slide", and, is also provided with a track along the upper and lower out sides to receive and permit movement of a transparent "indicator". The frame has two calibration scales on its face, one an "INDEX" scale and the other a "Loading Range" scale. The frame is plainly labeled with the airplane model for which it is designed, and is to be used for balance calculations on any airplane of that specific model.

(2) The "slide" is provided with a tongue on each side to secure and permit longitudinal movement within the "frame". The following calibrated scales are usually located on the face of the slide:

(a) Gasoline and Oil Scales - "Zero Gallons" is indicated by a short vertical line with an arrow pointing to it and is located at the end of a horizontal fuel line calibrated in both U.S. and Imperial gallons.

(b) Stowage and Extra Crew Scales - The "Zero Load Line" is usually a heavy vertical line with the scale title printed adjacent in bold face type. From this zero line are projected the different compartment loading scales calibrated in pounds.

(c) Crew Change Scale - A crew change scale is usually provided, with correct compartment nomenclature printed at each calibration mark. This scale is calibrated to move one member of the crew (200 lb.) between any compartments in the airplane.

(3) The "indicator" is a moveable transparent slide that may be shifted longitudinally along tracks cut in the upper and lower sides of the frame. It is marked with a hair line scribed vertically through its center.

c. Operating Instructions. (1) The principal of operation of the load adjuster is to determine that the distribution of additional weight over and above the basic weight of the airplane will insure the airplane balance falling within permissible cg limits. Items loaded in the airplane will be calculated on the load adjuster in the following sequence:

(2) Place the indicator on the correct basic airplane INDEX number. (Secure from identification card in the carrying case).

(3) Addition of gasoline load.

(4) Stowage of extra crew or extra load items, such as bombs, droppable fuel tanks, etc.

(5) Crew change.

(6) The operation of the load adjuster may be best explained by working out the following example:

(a) <u>Given:</u>	Basic Weight	31,815 lb. (INDEX setting 2.68)
	Gasoline (3100 U.S. gal.)	18,600 lb.
	Baggage (nose)	100 lb.
	Mail (Flight Deck)	300 lb.
	Passengers (15):	
	5 in Forward Bomb Bay	1000 lb.
	5 in Rear Bomb Bay	1000 lb.
	5 in Crew Compartment	1000 lb.
		<hr/> 53,815 lb.

To Find: If the load distribution brings the airplane balance within CG limits as indicated on the load adjuster by the "Loading Range" scale:

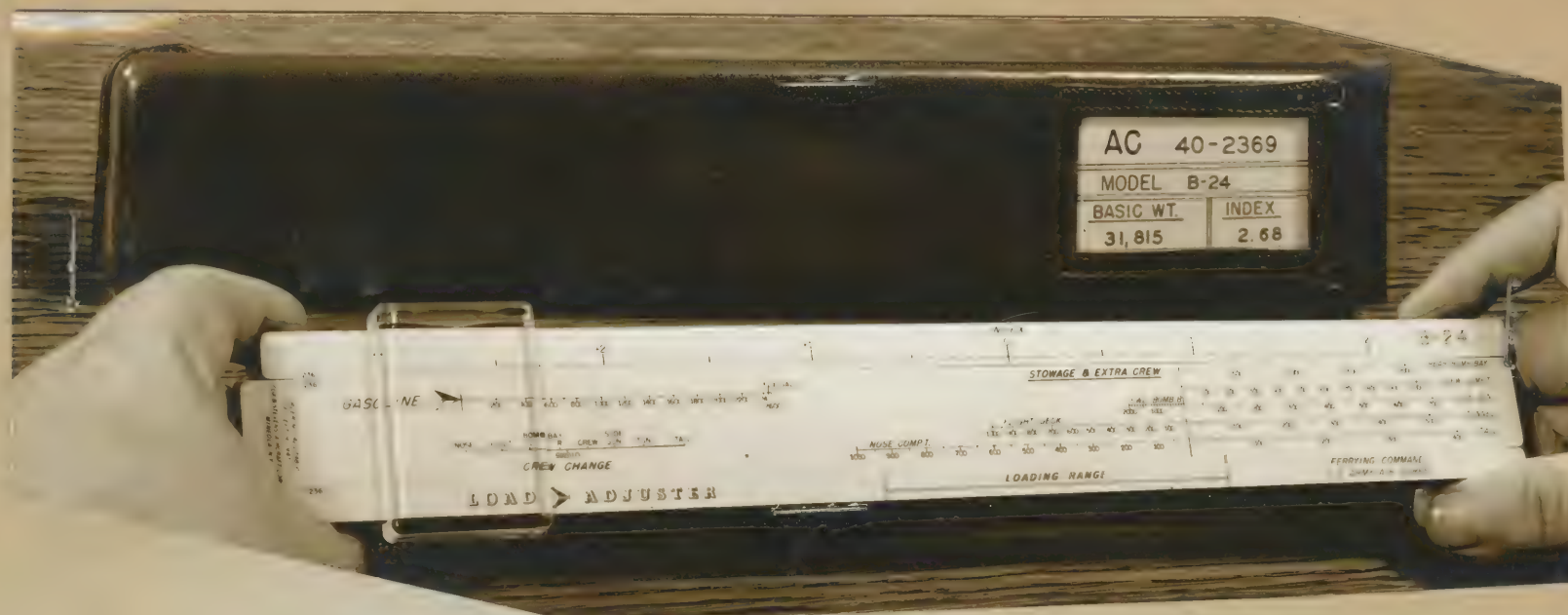


FIGURE 1

- (b) Start by moving the indicator until the hairline is over 2.68 on the index scale.

CAUTION: Extreme care must be exercised to preclude accidental movement of the indicator while adjusting the slide and vice versa. (The indicator represents the balance of the airplane as each item is "loaded".)

- (c) Move slide until its vertical line is at the beginning of "gasoline" scale under the hairline of the indicator. (Refer to Fig. 1)

- (d) Move indicator until the hairline is over 3100 gallons. This adds the balance moment of 3100 U.S. gallons of gasoline.



FIGURE 2

- (e) Move slide until the vertical line dividing the "Stowage and Extra Crew" scales (hereafter called the "Center Line") is under the hairline of the indicator. (See Fig. 2)

CAUTION: After each item is "loaded" by movement of the indicator, return the slide to the center line before "loading" the next item.

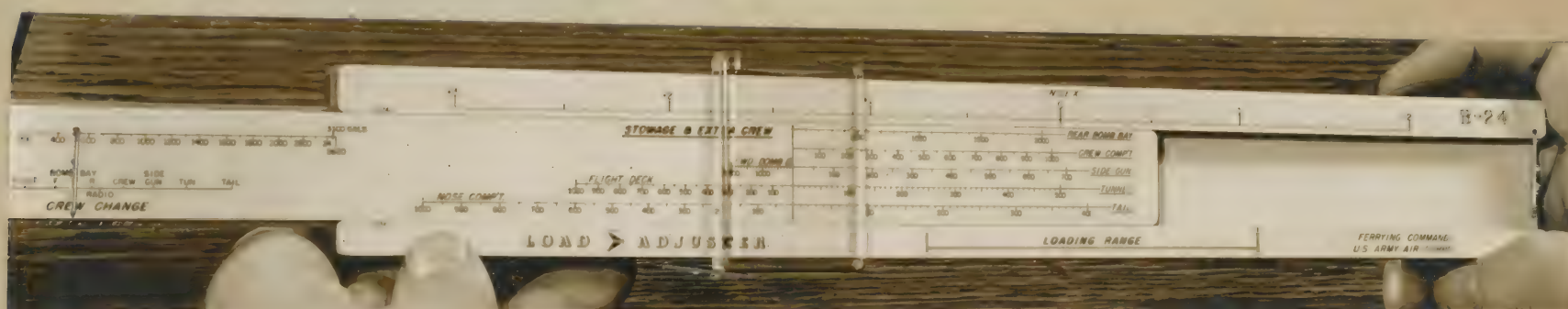
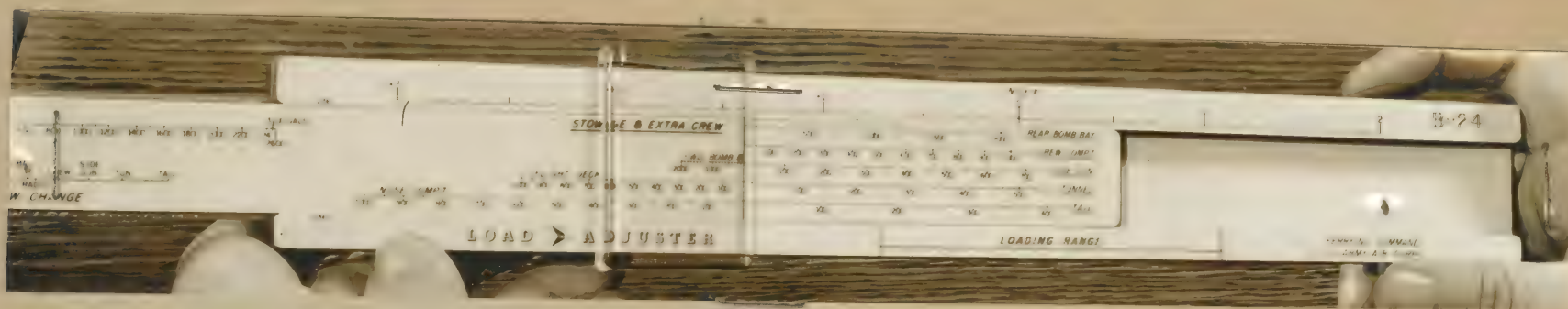


FIGURE 3

- (f) Move indicator until hairline is over 100 on the "Nose Compt." scale. This adds the balance moment of 100 pounds of baggage in the nose compartment. (Refer to Fig. 3)

- (g) Move slide until the center line is again under the hairline of the indicator.

CAUTION: Do not move slide accidentally while moving the indicator or vice versa.



(h) Move the indicator until the hairline is over the 300 on the Flight Deck scale moment of 300 pounds of mail under the flight deck. (Refer to Fig. 4)

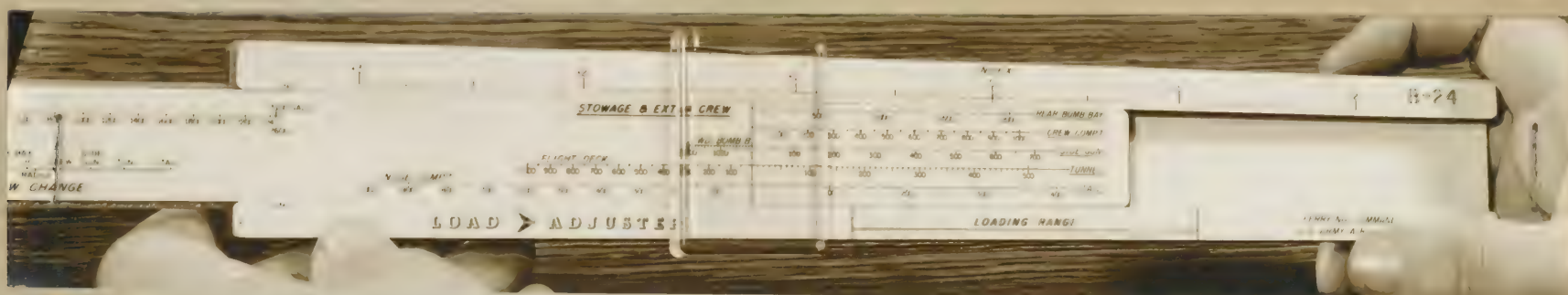


FIGURE 5

(i) Move slide until the center line is under the hairline of the indicator. NOTE: Figure 4 shows the position of the indicator, as in paragraph (h), and before the slide was moved as in (i). All other figures shown are taken after the slide was moved so that the center line is under the hairline of the indicator.

(j) Move indicator until it is over 1000 on the "Fwd. Bomb Bay" scale. This adds 5 passengers at 200 pounds each, or 1000 pounds balance moment in the forward bomb bay compartment.

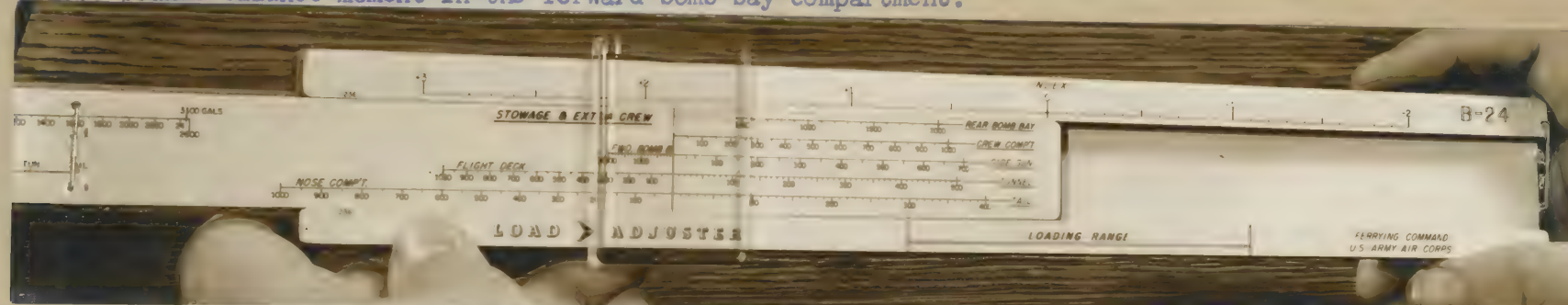


FIGURE 6

(k) Move slide until center line is under the indicator hairline. (Refer to Fig. 6)

(l) Move indicator until it is over 1000 on the "Rear Bomb Bay" scale. This adds 5 passengers at 200 pounds each, or 1000 pounds balance moment in the rear bomb bay compartment.

NOTE: If the operator will note the position of the indicator hairline in regards to the index scale after each item is "loaded", it can be seen that the load was considerably too far forward for proper balance. However, on the operation just completed, the balance moment is beginning to move to the rear closer to the loading range.

(m) Move slide until center line is under the indicator.

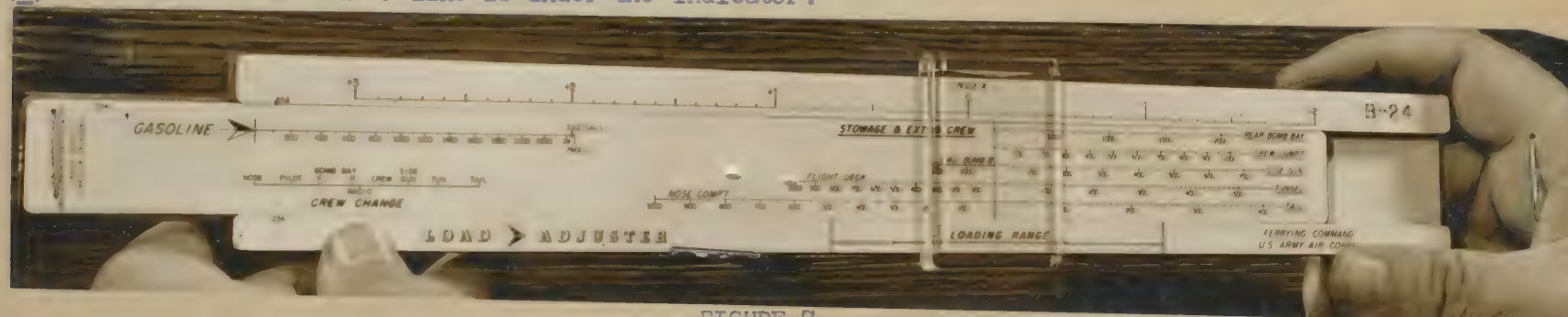


FIGURE 7

(n) Move indicator until it is over 1000 in the "Crew Compt." scale. This adds 5 passengers at 200 pounds each, or 1000 pounds in the crew compartment.

(o) Move slide until center line is under the indicator. (See Fig. 7)

NOTE: It will be observed in figure 7 that this last operation placed the hairline of the indicator almost in the center of the loading range scale. This shows that the load distribution is satisfactory because the hairline on the indicator is within the "Loading Range" limits.

2. INSTRUCTIONS FOR USE OF GRAPHS WHEN COM- PILING FORM "F"

NOTE: It is not necessary to use the graph system when a load adjuster is available.

1. Station, Bomb, Gasoline & Oil Graphs
(Form "E")
These graphs are read in the following manner, and all moments should be immediately entered in the appropriate blank space provided in Section X of Form "F".

(1) Note the weight of each item being loaded on the "WEIGHT (IBS.)" column along the right-hand margin of the Station Graph of Form "E".

(2) From this vertical position extend a horizontal line to the left until it meets the slanting curve line for the station where the load is being placed.

(3) From this point extend a vertical line down to the "MOMENT (1000 in. IBS)" scale at the bottom of the station graph.

(4) At this point read the moment of each item as it is being loaded.

1. Station, Bomb, Gasoline & Oil Graphs (Form "E")

These graphs are read in the following manner, and all moments should be immediately entered in the appropriate blank space provided in Section X of Form "F".

(1) Note the weight of each item being loaded on the "WEIGHT (IBS.)" column along the right-hand margin of the Station Graph of Form "E".

(2) From this vertical position extend a horizontal line to the left until it meets the slanting curve line for the station where the load is being placed.

(3) From this point extend a vertical line down to the "MOMENT (1000 in. IBS)" scale at the bottom of the station graph.

(4) At this point read the moment of each item as it is being loaded.

2. Crew Movement Table of Moments: This table gives moments in 1000 pounds for the constant ()

movement of one 200 pound man, either forward or rearward, from any station to any other station.

(1) If the moment after corrected changes in the "SUMMARY" (SECTION "W" OF FORM "F") is too small, the cg of the airplane is too far forward, and one or more members of the crew must be moved aft, and the moment developed must be ADDED. If the moment is too large, the cg of the airplane is too far aft, one or more crew members must be moved forward, and the moment SUBTRACTED.

NOTE: Changes of crew from station to station do not involve any change in gross weight, but only affect the moments of balance to permit taking off or landing within allowable airplane balance limits.

2. Center of Gravity (cg) Graph: The location of curves on this graph indicates minimum and maximum moments of balance allowable for take-off or landing conditions. The airplane gross load (addition of airplane basic weight plus all items of load) will not be greater than the highest figure shown in the "Weight (IBS)" column. The chart should be used in the following manner:

(1) Transpose total of all weight and balance figures from Section "X", "Y" & "Z" (Form "F") to the "SUMMARY" (SECTION "W") column (Form "F"). Make additions as applicable opposite "TOTAL LOAD (UNCORRECTED)" title. Plot the resultant total "WEIGHT & MOMENT OR INDEX" on the "CENTER OF GRAVITY

GRAPH". The center of gravity (cg) for the load is determined in a manner similar to that described for graphs in paragraph 2, b. above, i.e.: From the total GROSS WEIGHT extend a horizontal line toward the left, and from the total MOMENT extend a vertical line up. If these two lines intersect at a point between the slanting lines labeled forward and rear limits, the balance of the airplane is satisfactory. If it does not fall within these lines it is mandatory to readjust the load. For landing conditions the horizontal and vertical lines must intersect at a point between the slanting broken line and the slanting line for the rear limit.

(2) Example of Correcting (out of Balance)

(a) If calculations show the airplane to be too tail heavy, but the gross load is within limits, move the tail gunner up to the nose compartment and subtract his moment change with the aid of "CREW MOVEMENT TABLE OF MOMENTS". Enter this moment change in "SECTION "U" CORRECTIONS" chart in Form "F". If subtraction of this amount of moment brings the new balance within limits when plotted on the "CENTER OF GRAVITY CHART", The Weight and Balance is satisfactory for Take-Off. If the change is insufficient, move additional members of the crew or shift enough of the airplane load forward to bring the balance moment within limits. The same procedure may be used when balancing the airplane for correct landing cg. Section "U" in Form "F" is provided for entry of "last minute" corrections with provisions for posting of these entries near the bottom of "SUMMARY, SECTION "W".

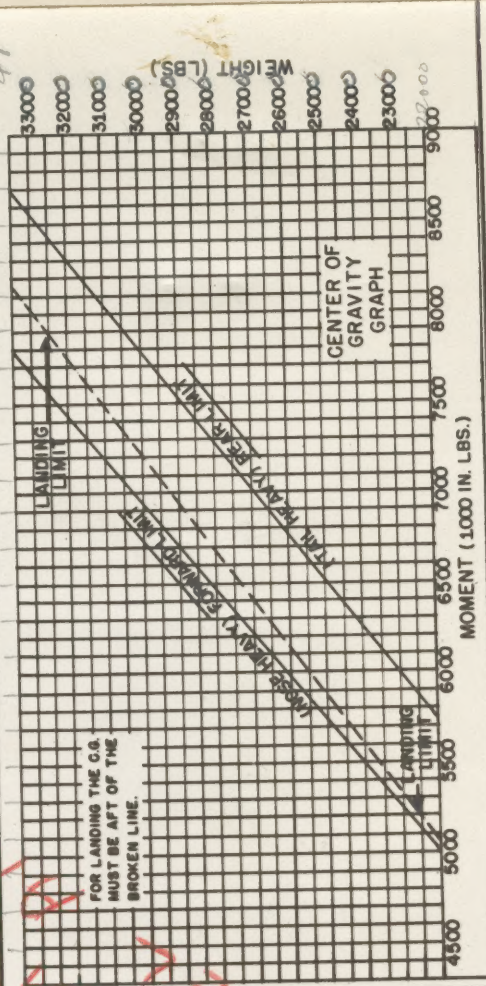
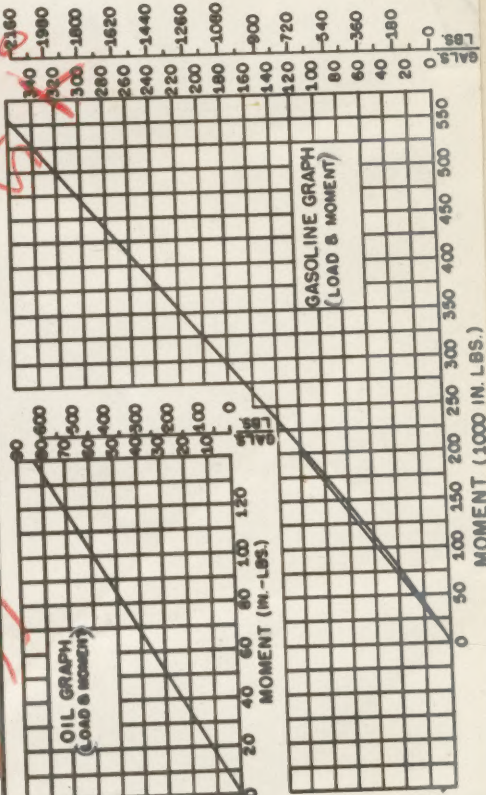
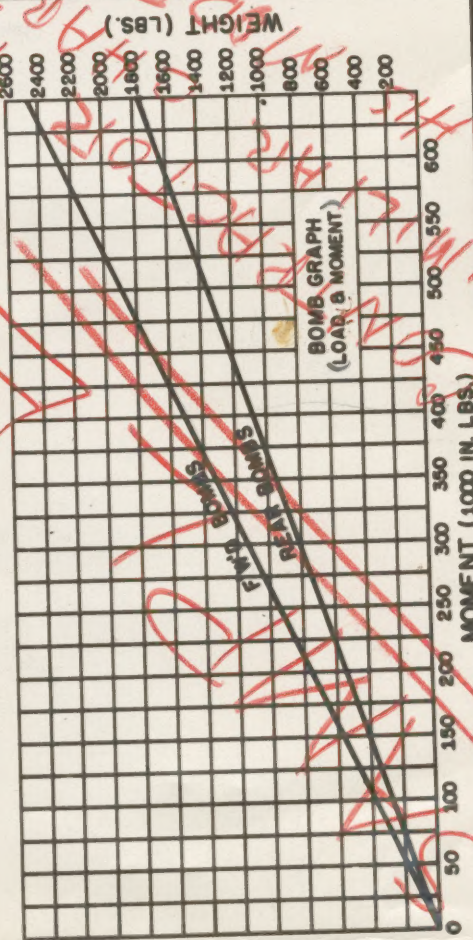
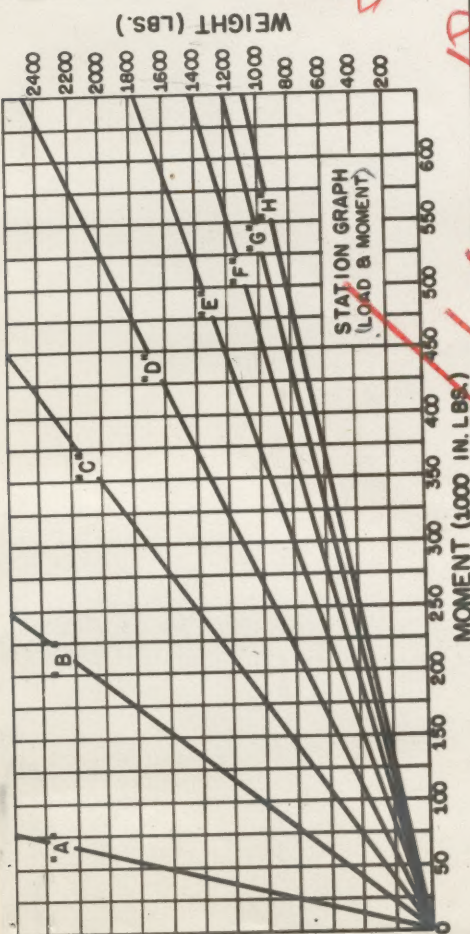
CHART E

CREW MOVEMENT TABLE OF MOMENTS

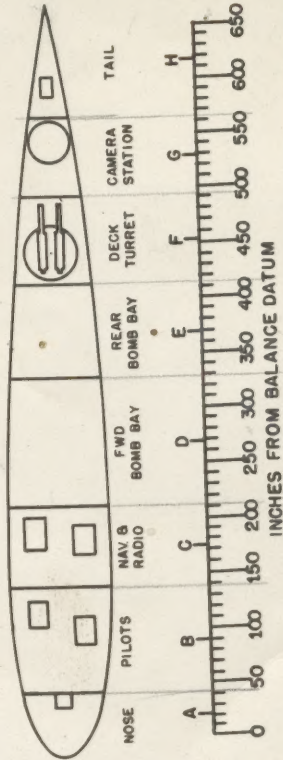
STATION	NOSE	FLIGHT	NAV. RAD.	TURRET	CAMERA
TAIL	118	105	86	32	16
CAMERA	103	90	71	17	
TURRET	86	73	54		
NAV. & RAD.	32	19			
FLIGHT	13				

USE TO COMPUTE CREW CHANGES
FOR ONE 200 POUND MAN

UNITS OF MOMENT FOR CREW CHANGE = 1000 INCH POUNDS
MOVEMENT OF CREW MEMBER AFT = PLUS (+) SIGN (ADD)
MOVEMENT OF CREW MEMBER FWD = MINUS (-) SIGN (SUBTRACT)



STATION DIAGRAM



CHARTS AND GRAPHS
FOR REFERENCE IN EXECUTING
FORM "A" - WEIGHT & BALANCE CLEARANCE
When No Load Calculator is Available REGISTERED

Comparison room note: Per reproduce this graph and over print the data indicated in red letters. This overprint should be in thin red lines this will not obliterate the basic subject matter. Chart is intended to be a sample only, the contractor is to make one for his particular model airplane along these same lines.

Section VIII

Section VIII

Page 1

INSTRUCTIONS FOR COMPILING FORM "F"

WEIGHT & BALANCE CLEARANCE

1. General.-

a. This form is used as a weight and balance clearance and controls the variable load items of the airplane such as crew, passengers, gasoline, oil, baggage, cargo, ammunition, bombs, etc. It is filled out in duplicate by the Crew Chief and is checked by Operations for each flight. On this form the "non-expendable" and the "expendable" items are separately grouped in order that a weight and balance for landing may be determined.

b. Form "F", Weight and Balance Clearance, is printed with certain variable information omitted. At the time of delivery of a new airplane the manufacturer will, by a second superimposed printing, fill in the following specific information pertaining to the specific airplane type for which the Handbook of Weight & Balance Data is issued for all sheets of Form "F" to be used on that specific airplane:

(1) The names: Nose, Nav., Flight, Radio, Turret, Tunnel, Tail, etc., of all the Stations, A to J, etc., under the Station letters in Section X (Station Loadings) and after the Station letters in Section W (Summary).

(2) Normal Capacity (lbs.) of Stations (A to J, etc.) in Section X (Station Loadings)

(3) Effect of Loadings on C.G. for Stations (A to J, etc.) in Section X (Station Loadings) are illustrated in the chart at the bottom of this page.

(4) Design Gross Weight and Maximum Allowable Weight in Section V (Limits).

c. On airplanes delivered prior to the installation of this system, the information listed above under (a) through (d) above will be printed in on Form "F" by A.A.F. weight and balance personnel.

d. For loading control Form "F" will be filled out according to the following instructions.

e. Fill in Form "F" prior to each flight.

- (1) Fill in Section Z (ammunition).
- (2) Fill in Section Y (bombs). Total each bomb bay separately (take moments from Graph when no load adjust is available).
- (3) Fill in Section X (station weights).

- (a) Enter weights of crew members (from Flight Form 1) at the proper station locations.
- (b) Enter weights of passengers and extra crew at proper station locations.
- (c) Enter baggage weights (from Form D) at proper station locations.
- (d) Enter cargo weights (from Form D) at proper station locations.

- (e) Enter ammunition weights (from Section Z)
- (f) Enter any special item not included in Forms D & F.

(g) Enter additions from total weight at each station, and total the weight of each station. If weight exceeds normal capacity of that station--rearrange load.

(4) Fill in Summary, Section W, (when not using Load Adjuster).

(a) Enter current basic weight and moment from Form C.

(b) Enter station weights from Section X (take moments from Graph).

(c) Enter Bomb weights, etc., from Section Y (take moments from Graph).

(d) Total weights and subtract from Design Gross or Maximum Allowable Weight to see how much gasoline and oil can be carried. If the gasoline and oil load is not sufficient, go back to Sections Z, Y, and X, or to Form D, to reduce loads there and change moments accordingly.

(e) Enter Gasoline and Oil (take moments from Graph).

(f) Total and check with LIMITS (see Graph).

(g) If limits are exceeded, reduce weight by removing cargo or gasoline and entering it in correction section. Enter any last minute correction in the same section. Calculate the net difference and enter in Summary Section of Form "F".

(h) Make any moment correction by crew change (Chart) and enter in proper place.

(i) Final figure must be attested.

(5) Summary, Section W, (when using Load Adjuster)

(a) Enter as above, but WEIGHTS only.

(b) Use Load Adjuster as per separate instructions.

(c) After each weight is added on the Load Adjuster, note the index in the index column.

(d) Watch C.G. position (Index) in relation to balance limits shown on Load Adjuster. Correct or shift crew as may be necessary, noting Index for corrections and also final load disposition.

Station	A	B	C	D	E	F	G	H	I	J	
Effect of Loading on C.G.	F'w'd Tendency			Rearward Tendency							→

(Form F)
One weight and Balance Clearance form will be
printed on this page and left there permanently.

WEIGHT & BALANCE CLEARANCE

MISSION FROM TO

DATE 10/1/41

AIRPLANE SERIAL 101

RUNNING TOTAL (FROM FORM C) 101

FORM 1

SUMMARY (SECTION W)

ITEMS: STATION A, B, C, D, E, F, G, H, I, J

WEIGHT OR INDEX

NON-EXPENDABLE LOAD

BOMBS - FWD BAY

- REAR BAY

DEPTH CHARGES

MINES

TORPEDOES

NON-EXP. PLUS BOMBS, ETC.

GAS - MAIN (GAL. @ 6.0)

- AUX. (GAL. @ 6.0)

- SPC. (GAL. @ 6.0)

OIL - TOTAL (GAL. @ 7.5)

TOTAL LOAD (UNCORRECTED)

CORRECTIONS (FROM SEC. U)

CORRECTED TOTAL

CREW CHANGES - (SEE CHART)

TAKE-OFF CONDITIONS

COMPUTED BY

APPROVED BY

PILOT

RESTRICTED

SECTION X (SEE GRAPH)

STATION LOADINGS OF "NON-EXPENDABLE" ITEMS

LOADINGS	STATIONS	A	B	C	D	E	F	G	H	I	J
CREW	LOCATION										
PASSENGERS @ 200 LB. EA.											
BAGGAGE (FROM FORM D)											
CARGO (FROM FORM D)											
AMMUNITION (FROM SEC. Z)											
STATION TOTALS											
NORMAL CAPACITY (LBS.)											
EFFECT OF LOADING ON C.G.											

SECTION Y (SEE GRAPH)

BOMBS, TORPEDOES, ETC.

ITEM	WEIGHT	MOMENT OR INDEX
FRONT BAY	() 10 () 50 () 100	
() 200 () 300 () 500		
() 600 () 1000 () 1100		
() 2000 () ()		
FRONT TOTAL		
REAR BAY	() 10 () 50 () 100	
() 200 () 300 () 500		
() 600 () 1000 () 1100		
() 2000 () ()		
REAR TOTAL		
DEPTH CHARGES		
MINES		
TORPEDOES		

SECTION Z

AMMUNITION

GUN	NO.	CAL.	STA.	RDS.	WT/RD	WEIGHT
NOSE						
BOW						
TOP						
LOWER						
SIDE						
TAIL						
WING						

SECTION U

CORRECTIONS

ITEMS	ADDED	REMOVED
STA.	WEIGHT	STA.
	MOMENT OR INDEX	WEIGHT
		MOMENT OR INDEX
TOTAL REMOVED		
TOTAL ADDED		
NET DIFFERENCE		

SECTION V

LIMITS

WEIGHTS	LBS.	LBS.
DESIGN GROSS		
MAX. ALLOWABLE		
C.G.	ALLOWABLE	ACTUAL
MOMENT (SEE GRAPH)	FWD	AFT
LOAD ADJUSTER	FWD	AFT
INDEX	FWD	AFT

SECTION W

WEIGHTS

WEIGHTS	LBS.	LBS.
DESIGN GROSS		
MAX. ALLOWABLE		
C.G.	ALLOWABLE	ACTUAL
MOMENT (SEE GRAPH)	FWD	AFT
LOAD ADJUSTER	FWD	AFT
INDEX	FWD	AFT

These forms to be made up in expendable books with provisions for an original and duplicate copy at each meeting, the former to be retained to permit removal and delivered to operations as a weight & Balance clearance.

On the last page of the handbook there must be printed one of these forms for the contractor to fill out on delivery of the airplane; this sheet is to remain in the handbook as a matter of manufacturing record and as a sample for filling out the expendable forms.

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